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ABSTRACT

The primary purpose of these guidelines is to provide teachers and other decision-makers with a suggested framework within which sound planning for metric education can be done. Student behavioral objectives are listed by topic. Each objective is coded to indicate grade level, topic, and objective number. A chart is provided to show a kindergarten through eighth-grade perspective as far as metric objectives are concerned. Topics dealt with include length, area, capacity, volume, weight, temperature, density, force, velocity, and acceleration. (MP)

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Guidelines For

Teaching Metric Concepts

by

The Wisconsin Metric Guidelines Committee

Wisconsin Department of Public Instruction
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Guidelines For

Teaching Metric Concepts

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THE UNITED STATES IS THE LAST MAJOR COUNTRY OF THE WORLD TO CONVERT to using the metric system (International System of Units). Legislation establishing metric education has been passed by the US Congress and by the legislatures of several states. It is only a matter of time before the US is predominantly metric. Metric education of school age children has already begun.

The primary purpose of these guidelines is to provide teachers and other decision makers a suggested framework within which sound planning can be done. It is expected that variances from school to school will exist which are based upon student capability and local educational expectations.

The specific student behavioral objectives listed here were created by a committee of mathematics and science educators representing the Wisconsin Mathematics Council, the Wisconsin Society of Science Teachers, and the Wisconsin Department of Public Instruction. Based on the best judgment of committee members, a grade level assignment of objectives was arbitrarily made and a prerequisite sequencing of objectives was maintained within each metric topic.

For several years US students will need to learn two systems of measurement, the traditional and the metric. These must necessarily be learned as separate, distinct systems, with no effort to convert units

Committee members are listed separately later in this article.

from one system to another during the learning of the systems. Conversion from English to metric units, and from metric to English units, should be done only as special *problem solving* activities at the secondary level, and should never be done as part of the elementary learning of the systems. Comparisons, such as meter to yard and quart to liter, can of course be made during learning. But solving problems such as "how many centimeters are there in five yards?" should be avoided until students are mature enough to handle complicated and abstract processes. Conversion within each system, however, is a necessary part of the system. Examples of this include changing 3 meters to 300 centimeters, 2 kilograms to 2000 grams, etc.

Teaching the metric system is a multidisciplinary responsibility, falling primarily within mathematics and science. Other disciplines should make applications of metric measurements.

The metric system should not be considered a unique and distinct subject within the school curriculum. Extra time does not have to be devoted to its teaching. It can be taught as an integral part of mathematics and science.

It is important that teachers understand the metric system before attempting to interpret these objectives or to teach metrics. Appropriate pre-service and in-service training must be supplied as needed. School districts should provide adequate in-service metric training and colleges and universities must provide adequate pre-service metric education.

It is assumed that teachers will provide students adequate and continuing review and reinforcement related to previously attained objectives. This should continue from grade level to grade level, especially during grades for which specific metric content objectives have not been identified.

A pedagogical development from use of arbitrary units of measure to selection and use of standard units of measure is imbedded in the objectives sequence.

The Student Behavioral Objectives chart is provided to show a kindergarten through eighth grade perspective as far as metric objectives are concerned. Topics are listed along the left side and suggested grade levels are identified across the top. Each objective's location is identified by a code, for example 3-W-2, which identifies grade level, topic and objective number in that order. Each objective is identified by the corresponding code identification as it appears in the list that follows the chart.

Not all base units of the International System are dealt with in this set of objectives. Those excluded are the ampere; the candella; the mole; and the second, except under velocity and acceleration. Density, velocity and acceleration are included at the upper grade levels because they illustrate the use of derived units to measure useful quantities. The unit of force is also a derived unit.

Student Behavioral Objectives (Metric)

Length

The students will:

K-L-1 Demonstrate an understanding that the *length* of a given object does not change regardless of the location or position of the object.

K-L-2 Compare lengths using terms such as "longer than," "shorter than," or "same as."

1-L-1 Use arbitrary (non-standard) units to measure length. For example, measure the length of a chalk tray in pencils, string segments, paces, finger spans, etc.

2-L-1 Use a ruler calibrated in centimeters (no subdivisions) to measure length.[1]

2-L-2 Read measures to the nearest centimeter.

3-L-1 Read and record a given length in centimeters using a numeral with the symbol *cm*. For example, the length of a paper clip is 3 cm.

3-L-2 Use a meter stick (or tape) to measure length to the nearest meter and to the nearest centimeter.

3-L-3 Record a given length in meters to the nearest meter using a numeral with the symbol *m*. For example the length of a room is 8 m.

3-L-4 Show that there are 100 centimeters in 1 meter.

4-L-1 Select standard units over arbitrary units to communicate lengths.

4-L-2 Use the kilometer to describe longer distances. For example, the distance between Madison and Milwaukee is 123 km.

4-L-3 Use a measuring device calibrated in millimeters.

4-L-4 Read measures less than 1 meter to the nearest millimeter.

4-L-5 Record a given length in millimeters using a numeral with the symbol *mm*. For example, a piece of paper is 215 mm wide.[2]

4-L-6 Show that there are 1000 mm in 1 m.

4-L-7 Show that there are 10 decimeters in one meter.

4-L-8 Convert measures given in meters to measures given in centimeters or decimeters.

5-L-1 Convert measures given in kilometers to measures in meters; convert measures given in meters or centimeters to measures in millimeters.

5-L-2 Round off measures given in millimeters or centimeters to the nearest meter.

5-L-3 Measure perimeters of physical objects using metric units.[3]

6-L-1 Convert measures given in millimeters to measures in centimeters; convert measures given in centimeters or decimeters to measures in meters; convert measures given in meters to measures in kilometers.

6-L-2 Round off measures given in millimeters to the nearest centimeter.

6-L-3 Order measures given in millimeters, centimeters and meters.

6-L-4 Use a surveyor's tape and a trundle wheel to measure distances in metric units.

6-L-5 Compute perimeters of polygons given the measures of the sides in metric units.

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[1] *The decimeter can be introduced as a unit for informal measuring at this stage of development, but this practice is not considered necessary to this sequence of metric objectives.*

[2] *The metric prefixes "deka" and "hecto" are not commonly used and thus do not appear in this sequence of objectives.*

[3] *At each grade level it is expected that students will actually measure lengths using appropriate instruments.*

8-L-1 Compute circumference of circles given the measures of the radii in metric units.

8-L-2 Estimate lengths with a reasonable degree of accuracy using centimeters or meters.

Area

The student will:

4-A-1 Indicate an understanding of the notion of area.

4-A-2 Determine areas of specified surfaces by covering the surfaces with arbitrary units. Examples of arbitrary units include books, sheets of paper, triangular-shaped objects, and discs.

4-A-3 Determine areas of rectangular surfaces by covering the surfaces with non-standard square units such as tiles.

5-A-1 State the dimensions of a square centimeter as one centimeter by one centimeter.

5-A-2 Determine areas of rectangular regions by covering the surfaces with square centimeters.

5-A-3 Determine approximate areas of non-rectangular regions by covering the surfaces with square centimeters.

5-A-5 Use the symbol cm^2 for square centimeter.[4]

5-A-6 State the dimensions of a square meter as one meter by one meter (or 100 cm by 100 cm).

5-A-7 Use the symbol m^2 for square meter.[4]

6-A-1 Measure the dimensions and compute the areas of rectangular regions using centimeters or meters.

6-A-2 Compute the areas of rectangular regions given the dimensions in any metric unit of length.

7-A-1 Compute the areas of common polygons given the required dimensions in metric units.

7-A-2 Compute the surface areas of rectangular solids given the required dimensions in metric units.

8-A-1 Compute the areas of circular regions given the radii in metric units.

8-A-2 Compute the surface areas of prisms, pyramids, cylinders and cones given the required dimensions in metric units.

8-A-3 Compute the area of arbitrary polygonal regions, given the required dimensions in metric units, by partitioning the region into common polygons and summing areas.

Capacity

The student will:

1-C-1 Show that an amount of liquid or granular substance does not change when it is poured from one container into a container of a different shape.

1-C-2 Compare the amounts of liquid or granular substance in two containers of the same size and shape by using the terms "same amount," "more than," and "less than."

2-C-1 Compare the capacities of various containers by filling the containers with a liquid or granular substance and place the containers in order from largest to smallest.[5]

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[4] *Pedagogically the use of "sq cm" and "sq m" probably will precede use of the symbol cm^2 and m^2.*

[5] *In the classroom, the concept of capacity precedes the concept of volume. In the metric system no distinction is made between liquid and dry capacity measures. Since the liter is defined as being equal to a cubic decimeter, in the upper grades the terms volume and capaicty are often used synonymously.*

2-C-2 Determine how many non-standard units (small container) it will take to fill a given container.

3-C-1 Identify a model of a liter from models that are smaller than 0.5 liter or greater than 1.5 liters.

3-C-2 Determine the capacity of a container to the nearest liter (e.g., use a model liter and a liquid or granular substance to fill a container).

4-C-1 Select standard units over arbitrary units to communicate capacities.

4-C-2 Use the symbol *l* for liter.

4-C-3 Use a graduated container to determine the measure of an amount of liquid or granular substance to the nearest one hundred milliliters.

4-C-4 Show that there are 1000 milliliters in 1 liter.

4-C-5 Use a graduated container to determine the capacity of a container to the nearest one hundred milliliters.

4-C-6 Use the symbol m*l* for milliliter.

4-C-7 Compare measures such as 250 m*l*, 1*l*, 3*l*, 200 m*l*, 1200m*l*, etc.

5 C-1 Convert measures given in liters to measures in milliliters.

5-C-2 Show that there are 1000 liters in 1 kiloliter.

5-C-3 Convert measures given in kiloliters to measures in liters.

6-C-1 Use a graduated container to determine the measure of an amount of liquid or granular substance to the nearest milliliter.

6-C-2 Use a graduated container to determine the capacity of a container to the nearest milliliter.

6-C-3 Convert measures given in milliliters to measures in liters; convert measures given in liters to measures in kiloliters.

Volume

The student will:

2-V-1 Show, given 2 three-dimensional figures of the same size and shape constructed from cubes (toy blocks, sugar cubes, etc.), that the number of cubes in each of the two figures remains constant even though the arrangment of the cubes in one or both of the figures may change.

2-V-2 Count the number of cubes in rectangular three-dimensional figures and non-rectangular three dimensional figures.

2-V-3 Compare the number of cubes in two or more three-dimensional figures using the terms "less than," "greater than," and "same as."

3-V-1 Build, given a set of blocks and a two-dimensional picture of a block structure, a block structure that is like the picture.

3-V-2 Determine the number of blocks in a three-dimensional structure from a two-dimensional picture of the structure.

5-V-1 Determine how many non-standard units (e.g., toy blocks, ping pong balls, milk cartons, books, etc.) it will take to fill a rectangular box.

6-V-1 State the dimensions of a cubic centimeter as 1 cm x 1 cm x 1 cm.

6-V-2 Use the cubic centimeter as a standard unit of volume.

6-V-3 Determine the volume of a rectangular container using wood or plastic models of cubic centimeters.

6-V-4 Select standard units over arbitrary units to communicate volumes.

6-V-5 Use the symbol cm^3 for cubic centimeter.

6-V-6 Determine the volume of a rectangular container by measuring the lengths of the edges to the nearest centimeter and using the formula: $V = l \times w \times h$.

6-V-7 State the dimensions of a cubic meter and cubic decimeter as 1 m x 1 m x 1 m and 1 dm x 1 dm x 1 dm respectively.

6-V-8 Use the cubic meter and cubic decimeter as standard units of volume.

6-V-9 Use the symbols m^3 and dm^3 for cubic meter and cubic decimeter respectively.[6]

6-V-10 Show that there are 1000 cm^3 in 1 dm^3.

6-V-11 Indicate that liter is another name for 1 dm^3 (1000 cm^3).

6-V-12 Indicate that milliliter is another name for 1 cm^3.

7-V-1 Determine the volume of a non-rectangular container by using a liquid or granular substance and the relationship 1 cm^3 = 1 *ml*.

7-V-2 Determine the volume of a solid object by the method of displacement.

7-V-3 Determine the volume of a rectangular container by computation using any appropriate metric unit.

8-V-1 Convert volume measures from larger to smaller or smaller to larger metric cubic units.

8-V-2 Estimate the capacity of a container in liters and/or milliliters with reasonable accuracy.

Weight

The student will:

K-W-1 Demonstrate having attained a concept of measurable quantities by asking questions such as "how much?" "how far?" and "how old?"

1-W-1 Demonstrate an intuitive feeling for weight as a measure of an amount of matter.

2-W-1 Indicate that the amount of matter in an object (such as a lump of clay) remains the same when the shape is changed.

2-W-2 Indicate that the amount of matter in an object will remain the same when it is broken into parts or when the parts are put back together to make the whole.

3-W-1 Use weight as an indication of the amount of matter in a given object.

3-W-2 Compare or classify objects by heft.

3-W-3 Use an equal arm balance to compare weights (masses).

4-W-1 Use the terms weight and mass as synonyms.[7]

4-W-2 Use an arbitrary unit to measure and compare weights.

4-W-3 Use the standard units gram and kilogram to describe weights.

4-W-4 Use *g* as the symbol for gram; use *kg* as the symbol for kilogram.

5-W-1 Use spring balances, kitchen scales and other devices to determine weights.

5-W-2 Select standard units over arbitrary units to communicate weights.

5-W-3 Convert measures given in kilograms to measures in grams.

6-W-1 Use the milligram to describe weight.

6-W-2 Use the symbol *mg* for milligram.

6-W-3 Convert measures given in grams to measures in milligrams; convert measures given in grams to measures in kilograms; convert measures given in milligrams to measures in grams.

6-W-4 Indicate that the kilogram is the *basic unit* of weight in S.I.

6-W-5 Define the kilogram as the weight of one cubic decimeter (liter) of pure water at 4 °C; also, the gram as the weight of one cubic centimeter of pure water at 4 °C.

6-W-6 Choose appropriate multiples of the gram to describe weight.

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[6] *"Cu cm," "cu dm," and "cu m" may precede the use of the symbols cm^3, dm^3, and m^3.*

[7] *In these guidelines the term "weight" is used as having the same meaning as the term "mass." Therefore, weight is taken to be different from force due to gravity. This is in line with the recommendation of the National Bureau of Standards.*

7-W-1 Estimate the weight of objects in appropriate multiples of the gram to a reasonable degree of accuracy.

7-W-2 Use calibrated weights with an equal arm balance and triple beam balance to determine the weight of a given object.

Temperature

The student will:

2-T-1 Read the room temperature or outdoor temperature to the nearest degree using a Celsius thermometer.

3-T-1 Indicate that temperature is a characteristic of all matter.

3-T-2 Use touch to order temperatures of substances.

4-T-1 Use a Celsius thermometer to measure the temperatures of a variety of places and things.

4-T-2 Use the symbol °C for degree Celsius.

4-T-3 Estimate environmental temperature in °C.

5-T-1 Describe the way by which expansion and contraction of liquids are used to indicate temperature.

5-T-2 Explain how relative temperature scales are developed.

5-T-3 Use a blank thermometer to locate the freezing and boiling points of water as reference points in order to develop the Celsius temperature scale.

6-T-1 Measure change in °C over time and communicate these measurements using a graph.

6-T-2 Use a blank thermometer and calibrate it in °C.

8-T-1 Describe Kelvin temperature as it relates to the Celsius temperature scale.

8-T-2 Equate the Kelvin and the °C.

8-T-3 Demonstrate volume change of a liquid as a function of temperature.

8-T-4 Graph change in the length of a column of liquid as a function of °C.

Density

The student will:

7-D-1 Demonstrate that objects with the same mass may have different volumes; also, objects with the same volume may have different masses.

8-D-1 Demonstrate that the ratio of mass to volume is a characteristic quantity of all substances.

8-D-2 Use the term density to mean the ratio of the mass of an object to the volume of the object.

8-D-3 Indicate that the unit for density is kg/m^3.

8-D-4 Convert measures given in kg/m^3 to measures in g/cm^3; convert measures given in g/cm^3 to measures in kg/m^3.

Force

The student will:

6-F-1 Describe force as a push or a pull.

7-F-1 Demonstrate that all objects on earth are attracted to the earth by a force of gravity and that the object attracts the earth with an equal force in the opposite direction.

7-F-2 Indicate the direction of a given force.

7-F-3 Demonstrate that forces are only detected when they cause an effect on matter.

8-F-1 Describe change in motion in terms of applied forces.

8-F-2 Use the newton as the unit of force.[8]
8 F-3 Use the definition of force: 1 newton acting on a mass of 1 kilogram causes an acceleration of 1 meter per second squared (m/sec^2).

Velocity

The student will:

6-v-1 Describe motion in terms of distance traveled and time.
6-v-2 Use the second as the basic metric unit of time.
7-v-1 Use basic units in mathematical operations to derive units such as m^2, m^3, and m/sec.
7-v-2 Differentiate between basic metric units and derived metric units.[9]
7-v-3 Determine velocity of a moving object using a metric ruler and stopwatch.
7-v-4 Indicate the direction of a given velocity.
8-v-1 Describe the conditions for uniform velocity.
8-v-2 Graph distance traveled over time for different uniform velocities.
8-v-3 Convert measures given in m/sec to measures in km/hr.

Acceleration

The student will:

8-a-1 Describe acceleration as a change in velocity.
8-a-2 Demonstrate that acceleration is zero when velocity is uniform.
8-a-3 Indicate that positive and negative accelerations are opposite in direction.
8-a-4 Demonstrate that acceleration of an object requires that a force be applied to the object.
8-a-5 Use m/sec^2 as the unit for acceleration.

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[8] *The newton is an example of a derived metric unit.*
[9] *The distinction between basic units and derived units applies to other quantities, but is included in these guidelines only in relationship to velocity.*

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Student Behavioral Objectives (Metric)

	To Be Accomplished By The End Of Grade:								
	K	1	2	3	4	5	6	7	8
Metric Length	K-L-1 K-L-2	1-L-1	2-L-1 2-L-2	3-L-1 thru 3-L-4	4-L-1 thru 4-L-8	5-L-1 thru 5-L-3	6-L-1 thru 6-L-5	*	8-L-1 8-L-2
Metric Area					4-A-1 thru 4-A-3	5-A-1 thru 5-A-7	6-A-1 6-A-2	7-A-1 7-A-2	8-A-1 thru 8-A-3
Metric Capacity		1-C-1 1-C-2	2-C-1 2-C-2	3-C-1 3-C-2	4-C-1 thru 4-C-7	5-C-1 thru 5-C-3	6-C-1 thru 6-C-3	*	*
Metric Volume			2-V-1 thru 2-V-3	3-V-1 3-V-2	*	5-V-1	6-V-1 thru 6-V-12	7-V-1 thru 7-V-3	8-V-1 8-V-2
Metric Weight	K-W-1	1-W-1	2-W-1 2-W-2	3-W-1 thru 3-W-3	4-W-1 thru 4-W-4	5-W-1 thru 5-W-3	6-W-1 thru 6-W-6	7-W-1 7-W-2	*
Metric Temperature			2-T-1	3-T-1 3-T-2	4-T-1 thru 4-T-3	5-T-1 thru 5-T-3	6-T-1 6-T-2	*	8-T-1 thru 8-T-4
Metric Density								7-D-1	8-D-1 thru 8-D-4
Metric Force							6-F-1	7-F-1 thru 7-F-3	8-F-1 thru 8-F-3
Metric Velocity							6-v-1 6-v-2	7-v-1 thru 7-v-4	8-v-1 thru 8-v-3
Metric Acceleration									8-a-1 thru 8-a-5

* Concepts and skills introduced in previous grades should be reviewed and expanded

The Wisconsin Department of Public Instruction Position on Metrication

The official conversion to metric measurement in the United States seems to be inevitable. Moreover, the problems of changing to a new system of measurement have strong implications for public education. Therefore, the Wisconsin Department of Public Instruction strongly supports activities in the schools that will contribute to an efficient and convenient transition. This support applies to changes in the use of units as they apply to the regular curriculum in all instructional areas and to measurements within school processes as well as to a new emphasis on direct teaching of the concepts and abilities that are necessary for individuals to use the International System of Units. Because the change will require that individuals be able to think and act using only metric units there should not be an emphasis on conversion or translation from one system of units to the other. Instead, school administrators and teaching faculty members should prepare their students for a time when there will be a complete dependence on the metric system in all aspects of measurement with only transitional and historical reference to the English system.

It is recognized that at the present time the time-table for the transition has not been established. However, this does not mean that it is too early for the public schools to react. Familiarity and competence with metric measurement now will make acceptance of the change much easier when it is legislated and put into effect.

[Extracted from "Conversion to the Metric System (A DPI Position Paper)", *Wisconsin Journal of Public Instruction*, Summer 1974.]

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